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SiC Material Properties Processed Via Dynamic Compaction With Pressureless Sintering

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Project Goals

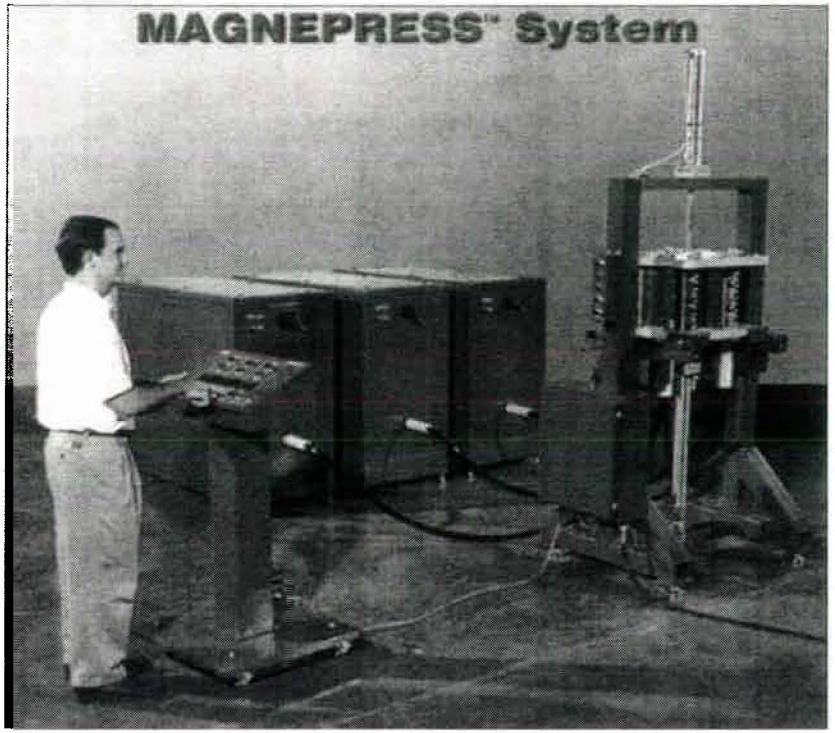
- Design and build a sub-scale DMC system to produce a near net shape flat (1x1x1/2") armor tiles
- Scale up the system to make 4x4x3/4" armor tiles
- Pressureless Sinter (PS) SiC tiles to full density
- Ballistic test 4x4x3/4" tiles and populate 3x3' array with tiles.

Outline

- What is the DMC process?
- Summary of Phase I Results
- Summary of work on sub-scale 1x1x1/2" system
- Material optimization effort with DMC-PS process
- Work in progress under phase II effort

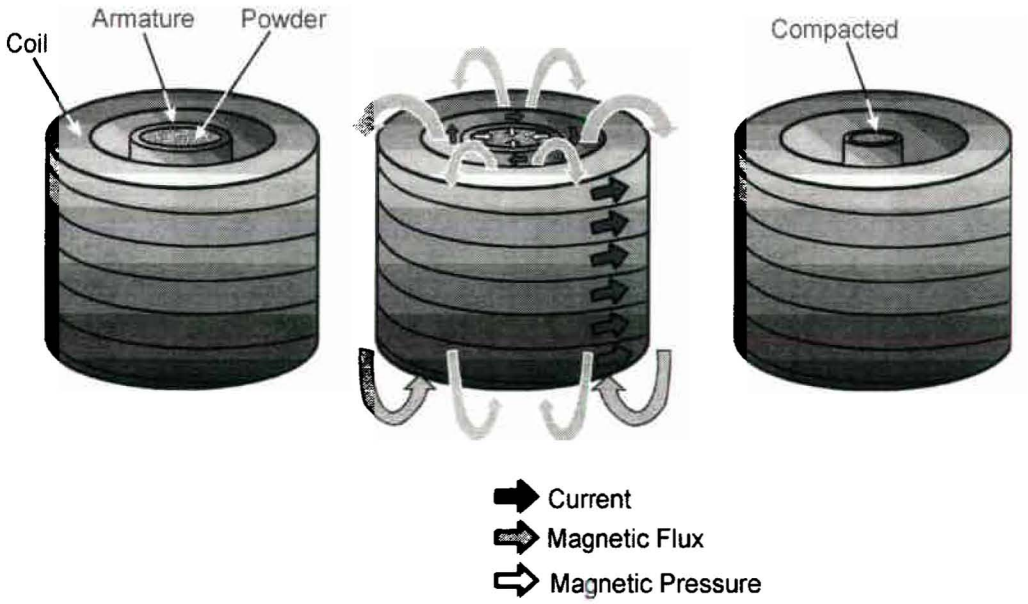
What is Dynamic Magnetic Compaction?

- Dynamic
  - Kinetic process
  - High compaction pressure for sub-millisecond
- Magnetic
  - Pulsed magnetics provide compaction energy
- Compaction
  - DMC delivers high density compacts
  - Fine microstructures



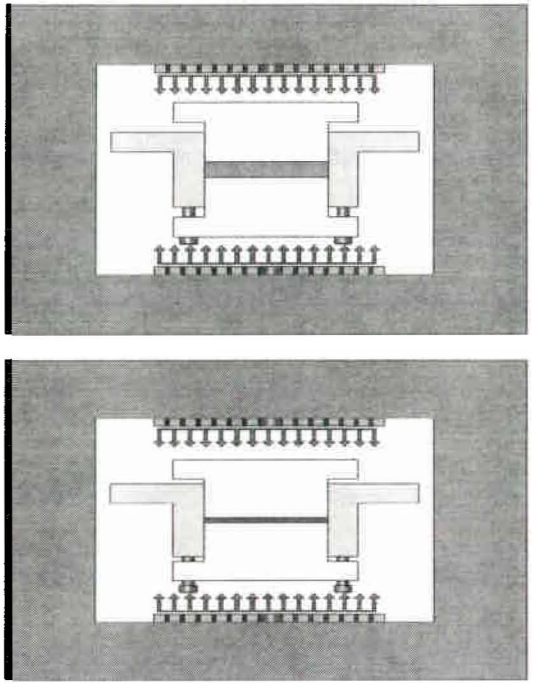
Fundamentals of DMC Pressing

Radial Compaction



- Net shaped cylindrical parts
- High L/D part shapes

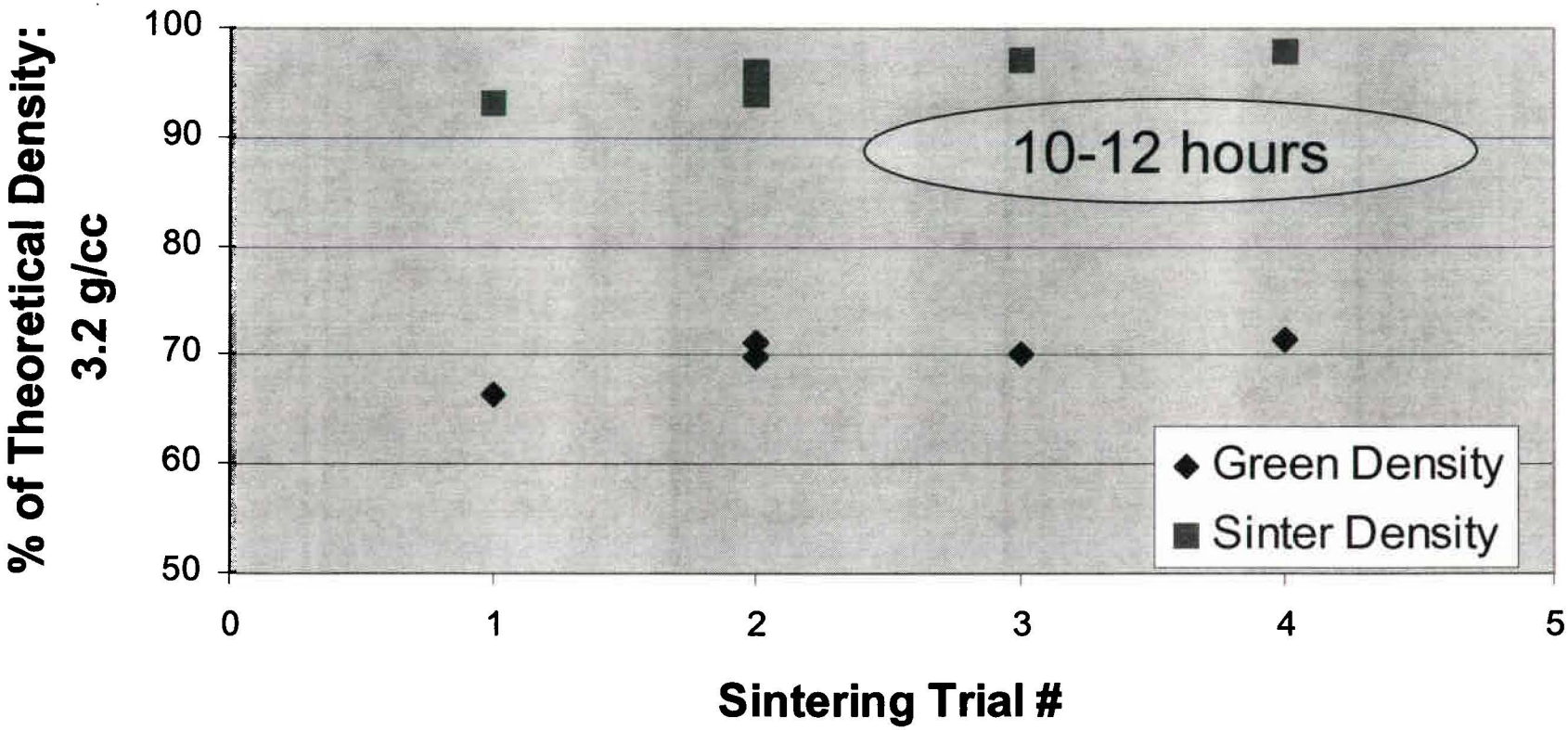
Axial Compaction



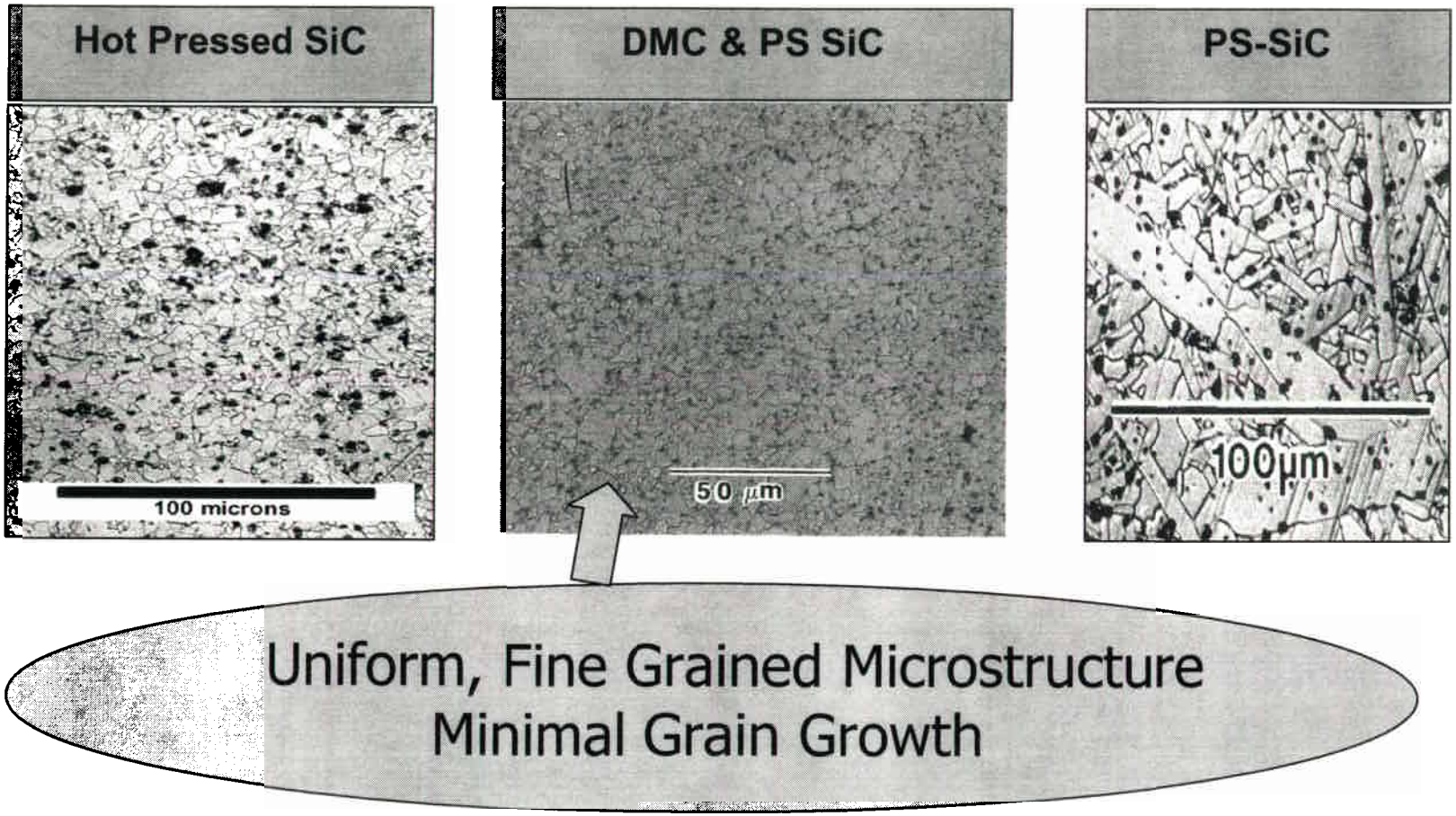
- Net shaped flat tiles

Phase I Results Summary-DMC/PS Compaction Densities

- HSC 490 NDP powders from Superior Graphite with binder, lube, and sintering aid



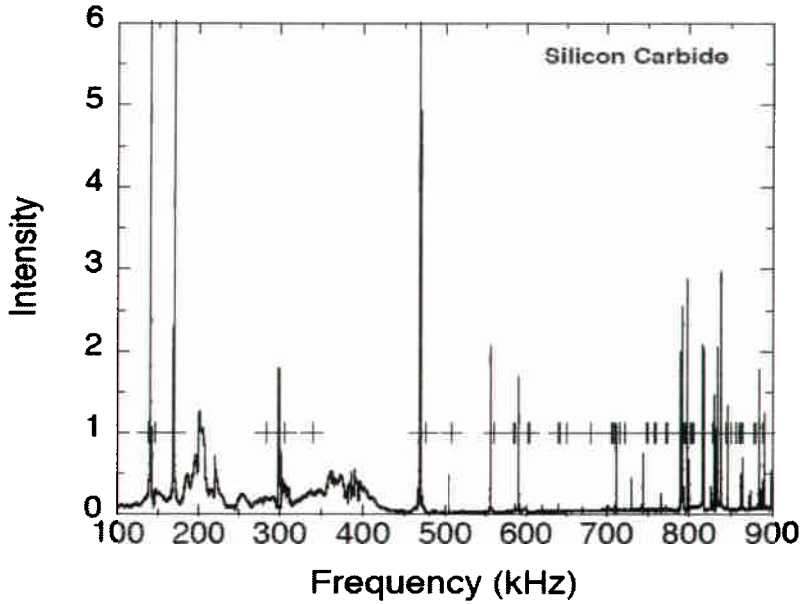
Phase I Results Summary-Microstructure of DMC/PS VS Conventionally Processed Samples



Summary of Phase I Results- Mechanical Properties Using Resonant Ultrasound Spectroscopy (RUS)

Material	Young's Modulus (GPa)	Poisson's Ratio
(DMC & PS) SiC 98.4% density	430	0.19
Cercom PAD SiC-N	460	0.16

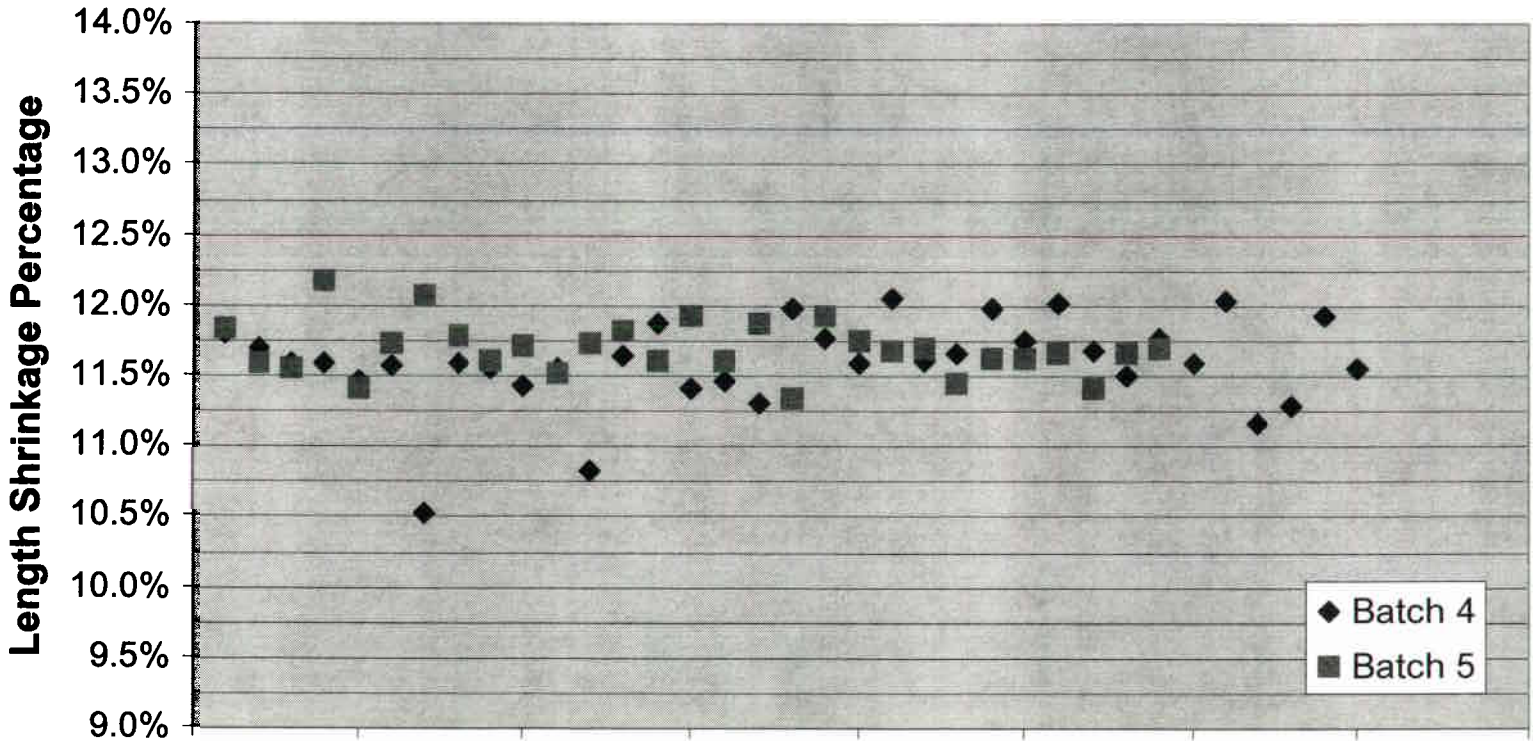
Consistent Elastic Properties



OSU conducted tests at Oak Ridge National Laboratories

Summary of Phase I Results- Predictable Shrinkage for Net Shape Fabrication

Shrinkage on 2" long parts; #Samples/set = 29 and 35.

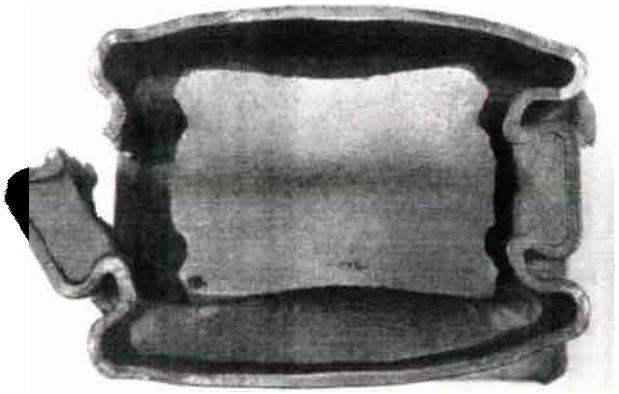


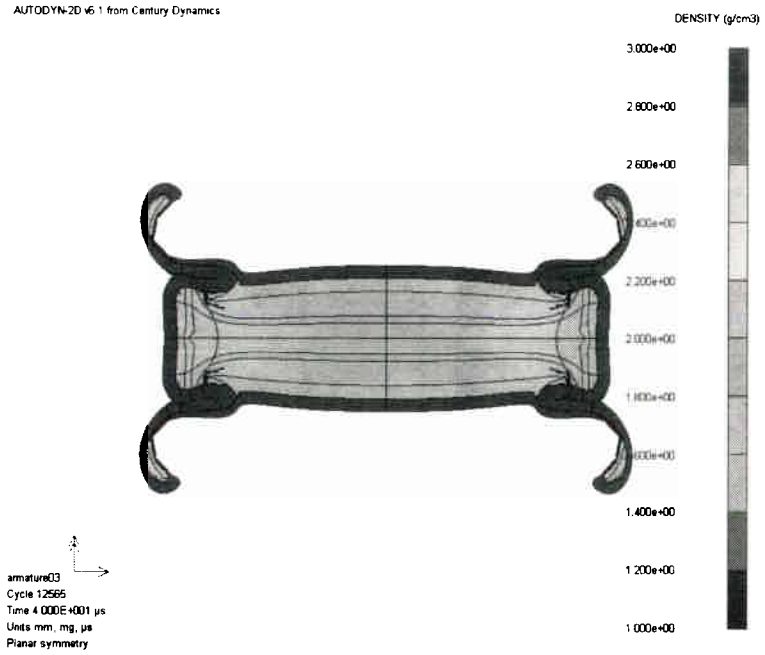
Sub-Scale Compaction System For 1”x1”x0.5” SiC Tiles

- FE Modeling
  - Magnetic Modeling
  - Dynamic Modeling
- Completed Final Design and Built Sub-Scale Flat Compactor
- Laboratory Testing of Flat Compactor in Progress

Dynamic Modeling of 1”x1”x0.5” Tile Agreed with Experiments

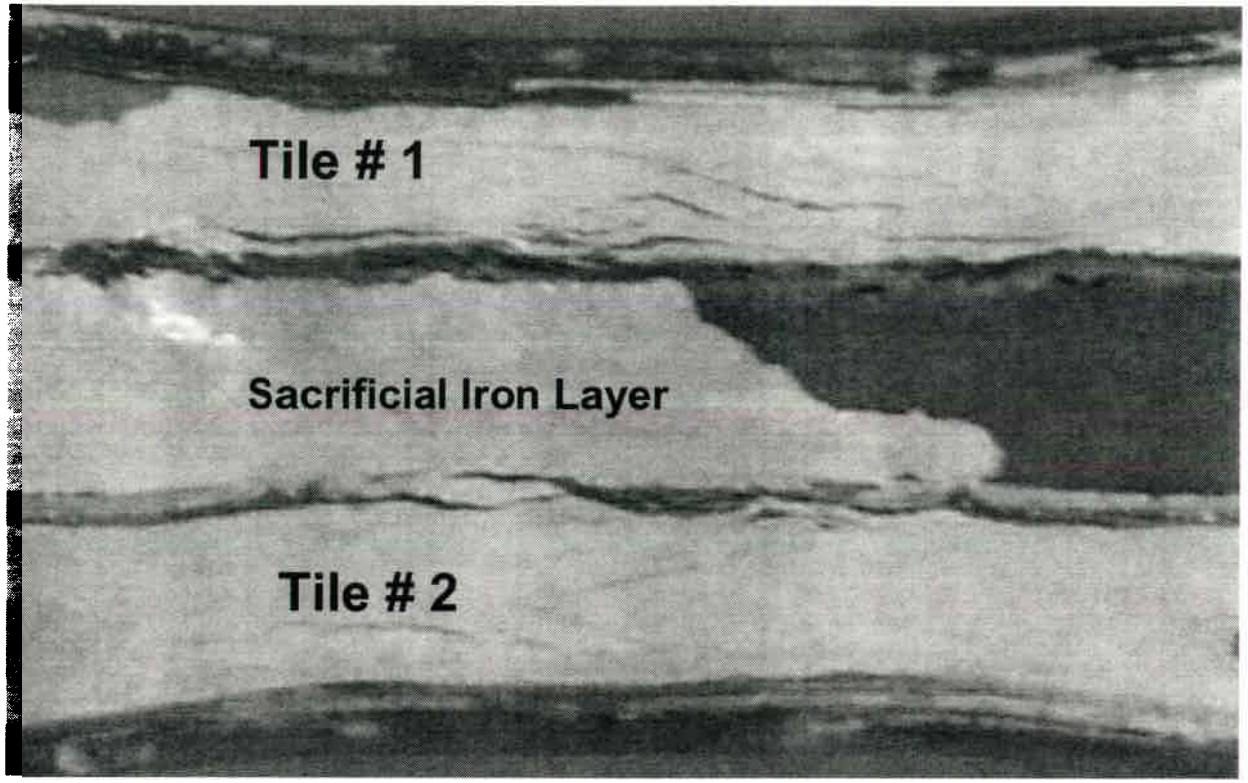
Powdered iron





- Sides of armature collapsed during compaction as per modeling

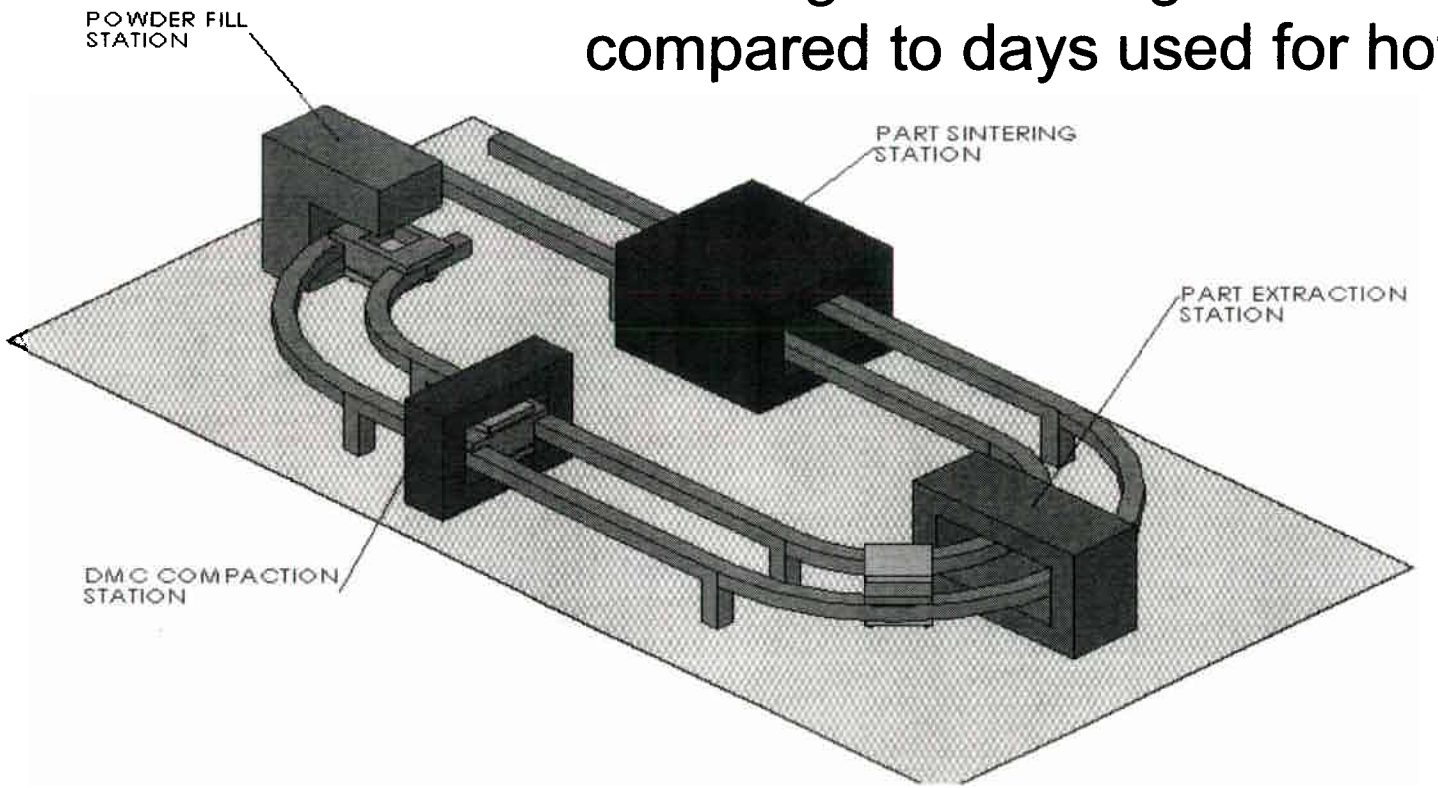
As Compacted 1x1x1/2" SiC Flat Tiles- Two Tiles in a Single Compaction



- Green Parts will be Pressureless Sintered (PS) and Characterized.

SiC Processing via Semi-Continuous Dynamic Magnetic Compaction

- DMC Compaction Time < 1 millisecond
- Sintering times using 1 to 3 hours compared to days used for hot pressing



Phase II Project Team

Powders

- Superior Graphite powders (made for Pressureless sinter (PS) with B and C additives)
- Ceramatec (Special powder chemistry for PS)

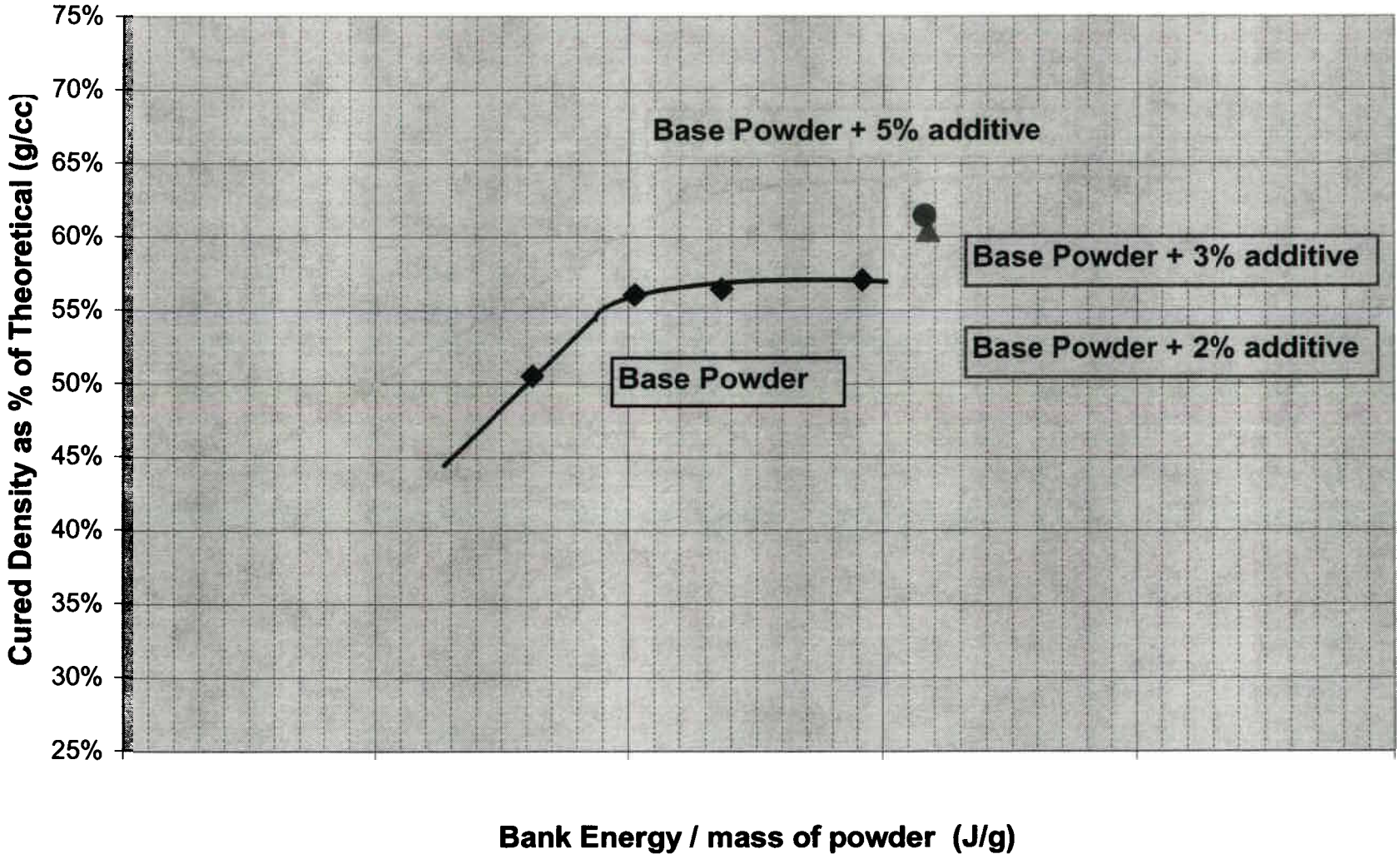
Sintering

- Microceramics and Ceramatec Inc

Testing

- Ceramatec, ORNL and UDRI

Green Density Optimization by Tailoring Powder Composition



Summary of Phase I and Option SBIR

- Successfully demonstrated DMC & PS ability to form dense ceramic materials
  - Microstructure and mechanical properties similar to hot pressed material
  - Dramatically reduced sintering time (10-12 hours vs. 4 days)
  - Repeatable shrinkage
- Phase I Option evaluated flat SiC tile production process for:
  - Increase production rates
  - Cost reduction due to net shape capability
  - Cost reduction due to dramatically reduced sinter times
- Phase II Work in Progress

SBIR Phase II Project Work

- Design and build a DMC system to make 4"x4" tiles
- Conduct ballistic tests on tiles
- Populate 3X3' Arrays for Ballistic Testing
- Concurrent Optimization
  - Powders
  - Process Conditions

Phase II Project in Progress

Future Work

- Nano Powder Additions
- Functionally Graded Tiles
- Alternate Tile Shapes

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